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ABSTRACT

This multi-level teacher's guide for the metric system was developed by a committee appointed by the Alabama Metric Education Advisory Council. It forms a core from which a comprehensive program of study and activities may be developed. Information in the guide includes: (1) a measurement overview: (2) goals and objectives of metric instruction, grades K-12: (3) a sequence chart: (4) explanation of the International System of Units: and (5) additional information in the form of materials lists (per grade level). There are also tables, charts, drawings, instructions for class-made items, and strategies for teaching. (MP)

"It is the official policy of the Alabama State Department of Education, including postsecondary institutions under the control of the State Board of Education, that no person in Alabama shall, on the grounds of race, color, handicap, sex, religion, creed, national origin, or age, be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any program, activity, or employment.

CURRICULUM GUIDE

METRIC MEASUREMENT

WILLIAM C. BERRYMAN, DIRECTOR
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4

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Montgomery, Alabama 36130

Wayne Teague
State Superintendent of Education

Dear Educator, President Ford
With the signing of the Metric Conversion Act by major industrial
in 1976, the United States completed the roster of committed themselves
nations who have either officially adopted or various other
to the use of the metric system. American industry and metric measurement,
governmental and private agencies are making use of their best interest
This rapidly increasing usage is proving to be to
and to the best interest of our country.

Although the metric system is different from the customary
measurement system, it is not basically strange to us. Our country,
at its founding, adopted a money system with currency denominations
related by tens.

As early as 1974, the United States Congress adopted the following:

It is the policy of the United States to encourage
educational agencies and institutions to prepare
students to use the metric system of measurement
with ease and facility as a part of the regular
educational programs.

In order to follow this policy, schools must:

1. Provide metric instruction that is continuous and consistent with learner development throughout the various grade levels;

2. Include appropriate instruction for students at all grade levels, immediately; instead of beginning at an early grade level only.

3. Recognize the interdisciplinary nature of measurement so as to provide metric instruction that is not limited to mathematics and science classes.

The curriculum guide which follows incorporates all the above features. This multi-level guide was developed by a committee appointed by the Alabama Metric Education Advisory Council and forms a core from which a comprehensive program of study and activities may be developed. Additional information in the form of materials lists (per grade level), tables, charts, drawings, instructions for class-made items, and strategies for teaching is provided.

Much success to you and your students in learning and using the metric system.

Wayne Teague
State Superintendent of Education

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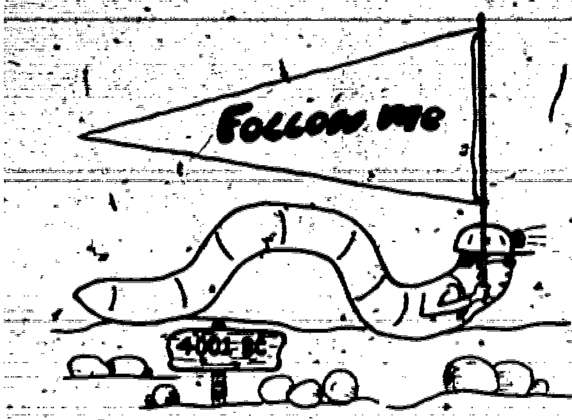
INDEX

7



MEASUREMENT OVERVIEW

4000-1100 BC
Egyptians measured with a knotted cord called a kite.

1700-1525 BC
Babylonians measured in cubits, the distance from a person's elbow to his finger tip. Grains of wheat were used to measure mass.

1700 BC
Hebrews also used cubits. Noah's ark was 300 cubits long.

500 BC
Phoenicians measured in zebos, or finger widths. Fifty zebos was a standard cloth measure. A nent, or armstretch, of 100 zebos made a fathom.

500 BC
The Greeks adopted the Phoenician zebo. They reduced the Phoenician cloth measure by five zebos so that the 45 zebo cloth measure was equal to three pous, or three footlengths. A fathom was 90 zebos or six pous long.

300 BC-300 AD
Since the Romans travelled long distances while building their empire, linear measure was an important part of their system. A soldier's boot became a standard unit. This foot length was equal to 12 finger widths. A pace, or double step, was equal to five feet. A thousand paces covered a mile and one eighth of that was the length of a furrow, or a furlong.

800 AD
In Germany there were many names for one measure based on the distance covered by the feet of 16 men when the men stood in line heel-to-toe heel-to-toe. Some of the names were rute, rod, pole, and perch. Forty of these units made a furlong and eight furlongs equaled one mile.

800 AD
Charlemagne declared his foot the standard foot length in his empire.

900-1100 AD
Trade became difficult. Each country had a different measuring system and every ruler made his own standards. A cup was usually the size of the king's favorite wine cup. A bushel was the size of a basket convenient to carry. Merchants never knew if they would get a good bargain. As trade increased, people tried to standardize measurement.

900 AD
Vikings spread the use of the fathom measure. A fathom was the distance from the finger tip on one hand to the finger tip on the other hand when a man's arms were outstretched.

900-1100
Every Anglo-Saxon who wore a sash carried a yard measure. But that meant that there were as many different yard measures as there were waistbands. King Edgar standardized the yard. He made it the distance from the tip of his nose to the end of his finger when his arm was stretched in front of him. The acre, to an Anglo-Saxon, was the amount of land plowed in one day by a pair of oxen. The amount of land plowed by a pair of oxen in one year was called a hide.

1714
Gabriel Fahrenheit, a German scientist, introduced a way to measure temperature. He put his thermometer, a glass tube with mercury in it, in a mixture of salt and ice. The cold made the mercury fall. Fahrenheit marked the place it stopped falling, 0°. Then he put the thermometer in his mouth. The heat made the mercury rise. He marked the place it stopped rising 100°.

1742
Around the same time, a Swedish scientist, Anders Celsius, was marking his thermometer differently. He marked 0° at the level of the mercury where water froze and 100° at the level of the mercury where water boiled.

In 1670, Gabriel Mouton, Vicar of Lyons, France, proposed a completely new measuring system based on multiples of ten. But it was not until after the French Revolution that a group of French mathematicians were able to fully develop this system of weights and measures. In 1790, they proposed the metric system, a decimal or base ten system, that used the meter as the basic unit. In 1795 the Metric System was adopted in France. Metric comes from the Greek word metron which means measure. A meter was based on 1/10,000,000,000 of the distance from the North Pole to the equator. In 1875, as the result of an international treaty, the International Bureau of Weights and Measurement was established in Sevres, France. A metal bar, made of a mixture of platinum and iridium, was declared the standard meter. Soon after, the standard gram and liter were established. In 1960 these standards were refined and the metric system was renamed the International Systeme of Units or SI for Systeme Internationale.

1964
The British announced their intention to adopt the Metric System over a ten year period.

1968
The United States Metric Study Bill was passed by Congress. The study recommended adoption of the Metric System over the next ten years.

1973

The Alabama Legislature adopted House Joint Resolution 250 "urging Alabama Educators to provide an opportunity for students to begin learning the universal metric system of measurement expected to be adopted officially in the United States in the near future."

1975

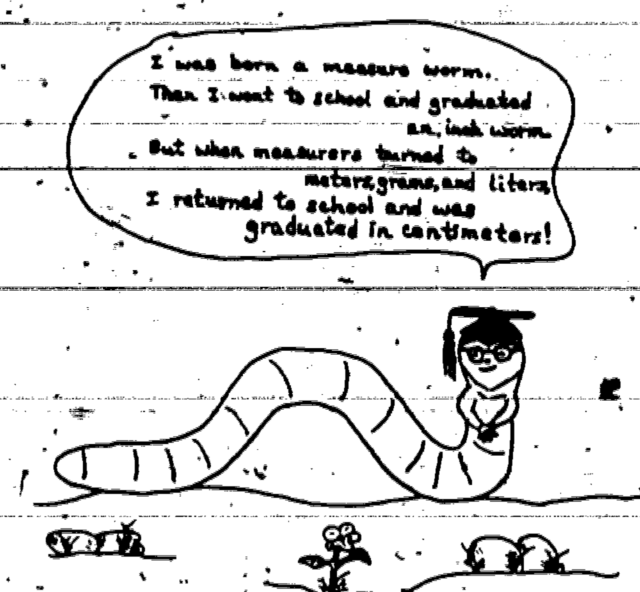
On December 23, 1975, President Gerald Ford signed the Metric Conversion Act of 1975. The Metric Conversion Act declares "—that the policy in the United States shall be to coordinate and plan the increasing use of the metric system in the United States and to establish a United States Metric Board to coordinate the voluntary conversion to the metric system."

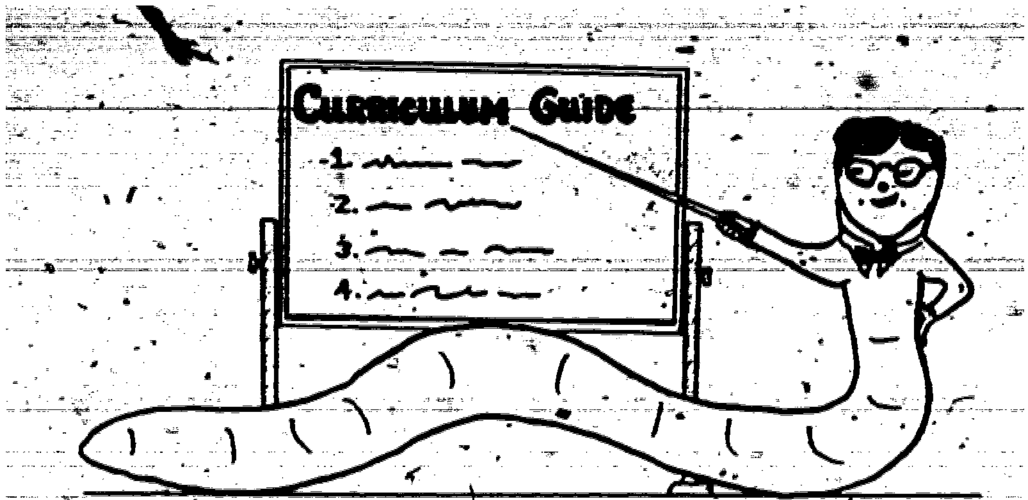
1976

An ad hoc Metric Education Advisory Committee for Alabama comprised of members from the State Department of Education, The Metric Institute of the University of Alabama, A.E.A., and P.T.A. recognized a need for specific guidelines on measurement education. At the direction of the committee, guidelines for metric instruction were produced. These appear later in this booklet.

1977

The United States Metric Board has not been named as of this date (August, 1977) but when established, it is likely that some manner of chronological schedule will be adopted to effect an orderly changeover to the International System of Units (SI). Industry has begun the conversion on its own and since our students will enter a work-world that is becoming increasingly related to metric measures, it behooves school systems to begin soon to move toward instruction in the metric system, also.





GENERAL GUIDELINES

1. The best way to learn measurement is to measure. This requires many hands-on activities that will familiarize students with different units of measurement by measuring actual objects found in their environment.

2. At all levels of instruction it is imperative that students progress from the concrete level (actual manipulation and construction of models whenever possible) to the semi-concrete (pictorial, scale drawings, etc.) to the abstract level of computation.

3. The metric system should be an integral part of the total curriculum in so far as it is concerned with measurement.

4. The metric system should be taught as the principal system of measurement with emphasis on the relationship among the units within the system. The children may compare metric units with other standard units but they should not convert from one system to another until sufficient need and motivation arise.

5. Estimation in measurement is a vital skill that should be stressed at each grade level.

GOALS AND OBJECTIVES OF METRIC INSTRUCTION, K-12

BROAD GOALS

Consistent with his developmental level, the student shall be able:

1. To know the language and symbols of the metric system and to communicate readily and effectively with acceptable form and style.

2. To apply the various relationships within the metric system.

3. To classify, order and compare on the basis of measurement attributes.
4. To estimate and measure length, area, volume, capacity, mass and temperature using appropriate instruments with metric scales.
5. To perform mathematical, scientific, and other operations that involve the use of metric measures.
6. To solve problems in his daily activities, at school and away, that involve metric measurement.
7. To be aware of the historical background of the change to metrics.
8. To appreciate the simplicity, consistency and efficiency of the metric system.
9. To perceive some of the economic, social and philosophic implications of world-wide adoption of a common measurement language and system.
0. To relate metric measures to those of other systems when he must interpret mixed data.

NOTES: The last goal is numbered zero as an indication that *conversion* is *not* a specific goal of this curriculum; conversion will be taught only when a particular need arises and never as an end in itself. The awareness that mixed data can be reconciled should be developed through the most generalized comparison consistent with the immediate task.

There may or may not be an objective to support each broad goal at every instructional level. Therefore, the numbering of the level objective is to be interpreted as follows: "1.3.3" refers to level 1, broad goal 3, third objective in support of goal 3; "5.5.1" refers to level 5, broad goal 5, objective 1 of 5 objectives to achieve the broad goal.

See page ten for suggested sequence of implementation of objectives.

LEVEL K OBJECTIVES

K.1.1 The student will pronounce the words: meter, centimeter, liter, gram and kilogram.

K.2.1 The student will recognize meter and centimeter as units for length.

K.3.1 The student will choose the longer (shorter) of two given objects relatively linear in nature. (Pencils, chalk, rods)

K.4.1 The student will select an appropriate object from a group of familiar objects when asked to choose one "about as long as a meter stick."

LEVEL 1 OBJECTIVES

1.1.1 The student will identify a meter stick that is labeled but not necessarily scaled.

1.1.2 The student will identify a centimeter division on a metric ruler.

1.2.1 The student will select both "meter" and "centimeter" as words related to a scaled meter-stick.

1.2.2 The student will associate "meter" and "centimeter" to length terms such as long, short, tall, high, wide, etc.

1.2.3 The student will associate "liter" to the measurement of liquids such as milk and water.

1.2.4 The student will associate "kilogram" to the measurement of mass (or weight!) on a beam or balance scale (or personal scale).

1.3.1 The student will directly compare two objects and classify one as longer than, shorter than, or equal to the other.

1.3.2 The student will compare and order* the length of pictorial representations of objects.

1.3.3 The student will compare and order areas directly by covering.

1.3.4 The student will compare and order mass directly using a simple scale.

1.3.5 The student will compare and order capacity directly by pouring.

1.4.1 The student will recognize a body referrent** for the meter and for the centimeter.

1.7.1 The student will describe the metric system as something "new" for everyone to learn.

LEVEL 2 OBJECTIVES

2.1.1 The student will read the words meter, centimeter, liter, gram and kilogram.

2.1.2 The student will select the symbol for the words meter and centimeter.

2.1.3 The student will read a Celsius thermometer in whole degrees.

2.2.1 The student will state the relationship between meter and centimeter.

2.2.2 The student will identify meter, centimeter, gram, kilogram, liter and Celsius as *metric* words.

2.2.3 The student will identify at least 5 situations in his environment that will involve *metric* measurement.

2.3.1 The student will compare and order 2 line segments using a centimeter ruler in whole units.

*Order—using greater than or less than qualities.
**Referrent—a body part or quality which approximates a known measure.

2.3.2 The student will compare and order 2 closed regions of *similar* shape by visual comparison.

2.4.1 The student will measure the length of a pictorial representation in whole centimeters.

2.4.2. The student will determine the capacity in whole liters of a given container by pouring with a liter cup.

2.4.3 The student will fill a graduated beaker or cylinder to the one liter mark.

2.4.4 The student will determine whether a small object has mass greater than, less than, or equal to a one kilogram weight using a simple scale.

2.7.1 The student will identify the metric system as the measuring system to be used most in the future.

LEVEL 3 OBJECTIVES

3.1.1 The student will select the word symbolized by m, L, g, and kg.

3.1.2 The student will place the six common metric prefixes in order on a place value chart. (kilo, hecto, deka, deci, centi, milli)

3.1.3 The student will identify freezing point, boiling point, body, and room temperatures on the Celsius scale.

3.2.1 The student will differentiate between km, m, dm, cm.

3.3.1 The student will compare and order measurements in square centimeters.

3.3.2 The student will compare and order the area of two rectangular regions with sides in whole centimeters using a centimeter grid.

3.4.1 The student will estimate lengths in centimeters.

3.4.2 The student will measure classroom distances to the nearest whole meter.

3.4.3 The student will measure distances less than one meter to the nearest decimeter.

3.4.4 The student will determine the area in square centimeters of a rectangle with sides in whole centimeters using a centimeter grid.

3.4.5 The student will measure a liquid correctly to the nearest 100 milliliters using a calibrated beaker or cylinder.

3.4.6 The student will determine the volume in cubic centimeters of a rectangular solid by counting centimeter cubes or by constructing a similar object with centimeter cubes.

3.4.7 The student will determine the perimeter of a rectangle or a parallelogram by measuring in whole centimeters.

3.4.8 The student will determine the approximate mass in grams of a small object using a balance scale to within 10 grams for objects of 100 grams or less.

3.4.9 The student will determine heights in centimeters and his own weight in kilograms.

~~3.5.1 The student will determine the sum and difference of two like measures.~~

3.6.1 The student will construct a line segment of arbitrary length in whole centimeters.

3.7.1 The student will recognize the metric system as a *measuring* system comparable to other systems.

LEVEL 4 OBJECTIVES

4.1.1 The student will state the six common metric prefixes and their meaning.

4.1.2 The student will select symbols that correspond to metric terms.

4.1.3 The student will identify temperatures as cold, very cold, warm, or hot.

4.2.1 The student will use the relationships L→mL, kg→g, $m^2 \rightarrow cm^2$, 1 L=1000 mL, 1 kg=1000 g.

4.2.2 Given an arbitrary temperature in whole degrees Celsius, the student will locate it on a Celsius scale.

4.3.1 The student will compare and order measurements in whole m^2, dm^2, and cm^2.

4.3.2 The student will compare and order measurement in dm^3 and in L.

4.4.1 The student will estimate lengths in m, cm, and mm.

4.4.2 The student will measure length to the nearest mm.

4.4.3 The student will estimate areas of triangular regions by counting units and half-units using a centimeter grid.

4.4.4 The student will calculate the perimeter in cm of irregular polygons.

4.4.5 The student will measure temperatures to the nearest whole degree.

4.5.1 The student will calculate multiples and submultiples (divisions) of metric measurements expressed in whole units.

4.5.2 The student will change from km→m→dm→cm→mm.

4.5.3 The student will change cm→dm, dm→m, mm→cm.

4.6.1 The student will solve simple word problems that involve addition and subtraction of metric measurements.

4.7.1 The student will state the approximate age and national origin of the metric system.

4.0.1 The student will identify the general correspondences: m→yd., cm→in., kg→lb., L→qt., °C→°F.

LEVEL 5 OBJECTIVES

5.1.1 The student will write the metric word to match each common symbol.

5.1.2 The student will recognize local seasonal temperature variations in °C.

5.2.1 The student will use the relationships:
km↔hm↔dam↔m↔dm↔cm↔mm, kg↔g↔mg, kL↔L↔mL.

5.2.2 The student will use the relationship dm^3↔L in capacity and L↔kg in mass of cold water.

5.3.1 The student will compare and order measures in m^3, dm^3, cm^3, kL, L, mL.

5.4.1 The student will make reasonable estimates of the length, mass, and capacity of common classroom items.

5.4.2 The student will read and record in °C the temperature of liquid as it is heated or cooled.

5.5.1 The student will fill a calibrated beaker or cylinder to an arbitrary measure.

5.5.2 The student will find the sum and difference of two measurements expressed in decimal notation.

5.5.3 The student will calculate the area of a rectangle using the formula, base×height=area, with measurements in whole units.

5.5.4 The student will express linear measurements correct to the nearest 0.1 m and 0.1 cm.

5.5.5 The student will change km→hm→dam→m→dm→cm→mm, kg→g→mg, kL→L→mL by multiplying by 10, 100, or 1000.

5.6.1 The student will solve word problems that involve multiplication of integers times metric measurements and division of metric measurements by integers using whole units only.

5.7.1 The student will explain *why* and *how* the metric system originated.

5.8.1 The student will identify the advantages of using a common set of prefixes with all root words.

5.0.1 The student will make the gross comparisons:
a *m* is a little *more* than a *yd.*, a *L* is a little *more* than a *qt.*, a *kg* is a little

more than *2 lbs.*, a *cm* is a little *less* than *half an inch.*

LEVEL 6 OBJECTIVES

6.1.1 The student will recognize these symbols as words: km/h, m/s, km/s.

~~6.1.2 The student will read metric road signs such as Speed Limit 80 km/h,~~ Montgomery 170 km.

6.1.3 The student will state linear dimensions of measurements such as: m^2, dm^2, cm^2, m^3, dm^3, cm^3. (Objects measured being squares or cubes.)

6.1.4 The student will construct and read a line graph showing variations in outdoor temperature over a period of time in °C.

6.2.1 The student will use the relationships $\text{ha} \rightarrow \text{a} \rightarrow \text{m}^2$, $\text{t} \rightarrow \text{kg}$.

6.2.2 The student will rename all common metric linear measurements in equivalent values including square and cubic units.

6.3.1 The student will compare and order measurements in the same base unit.

6.4.1 The student will select an appropriate unit of measurement for common objects in his environment from the set: km, m, cm, mm, kg, g, L, mL.

6.4.2 The student will heat a liquid to an arbitrary °C temperature.

6.5.1 The student will calculate the volume of a rectangular solid using metric measurements in decimal notation.

6.5.2 The student will perform multiplication and division operations on metric measurements expressed in decimal notation.

6.5.3 The student will change $cm^2 \rightarrow dm^2 \rightarrow m^2 \rightarrow a \rightarrow ha$, $kg \rightarrow t$.

6.5.4 The student will express linear measurements correct to 0.001 m and 0.001 km; capacity measurements to 0.001 L and mass to 0.001 kg.

6.5.5 The student will calculate the area of a rectangle with sides expressed in decimal notation.

6.6.1 The student will calculate the area of triangles, parallelograms and trapezoids using base-height formulas and whole metric units.

6.6.2 The student will make a graph to show comparisons of metric units.

6.7.1 The student will recite some of the historical development of the metric system.

6.8.1 The student will explain the concept and value of a decimalized system.

6.9.1 The student will recognize the advantages of a world-wide measurement system in world communications.

6.0.1 The student will be able to compare English to metric measures given an appropriate printed comparison chart.

LEVEL 7/8 OBJECTIVES

7/8.1.1 The student will identify all the metric base terms.

7/8.1.2 The student will state the prefixes in sequence.

7/8.1.3 The student will read, spell, and know the meaning of the common metric prefixes and root words, and pronounce them properly.

7/8.1.4 The student will identify normal body temperature and local climatic ranges in degrees Celsius.

7/8.1.5 The student will read and record metric measurements using accepted symbols and form.

7/8.2.1 The student will associate the prefixes to their multiplication constants.

7/8.2.2 The student will read [illegible] interpret charts, graphs, and diagrams showing data in metric terms.

7/8.2.3 The student will convert to any arbitrary equivalent metric unit given any common metric measurement.

7/8.2.4 The student will read and interpret maps bearing metric scales.

7/8.3.1 The student will compare and order groups of measurements in equivalent units.

7/8.3.2 The student will describe and compare physical areas of his environment, such as athletic fields, courts, classrooms, etc., in metric terms.

7/8.4.1 The student will calculate the volume of irregularly shaped solids by liquid displacement in a graduated beaker or cylinder.

7/8.4.2 The student will state his height in either m or cm and his weight in kg.

7/8.4.3 The student will read and calculate temperature changes during laboratory experiments using a Celsius lab thermometer.

7/8.4.4 The student will measure various volumes using laboratory graduated beakers or cylinders.

7/8.4.5 The student will weigh various objects using a laboratory balance and calculate weight differences using metric units.

7/8.5.1 The student will approximate distances between two points on a map bearing a metric scale.

7/8.5.2 The student will make all common changes from one metric unit to another by moving the decimal point.

7/8.6.1 The student will use metric measurement in simple algebraic equations and geometric formulas.

7/8.6.2 The student will use metric measurements in such daily activities as class projects, art works, handicrafts, vocational training, sports, and hobbies.

7/8.7.1 The student will trace the progress of the metric system in the U.S. and in the world.

7/8.8.1 The student will compare the metric system to the English system in terms of simplicity and ease of use.

7/8.9.1 The student will describe how the use of the metric system will facilitate international travel.

7/8.9.2 The student will explain the advantages of the adoption of the metric system in relation to industrial production and world trade.

7/8.9.3 The student will state the implications of a common measurement system in terms of setting world-wide standards in such areas as medicine, economic development, ecological planning, etc.

7/8.0.1 The student will interpret mixed data by translating non-metric data to a metric approximation of appropriate accuracy using given formula, chart or scale.

LEVEL 9/10/11/12

No specific objectives are stated here. It is expected that teachers will select from the foregoing lists those objectives sufficient to overcome deficiencies and meet the needs of students in high school grades.

19

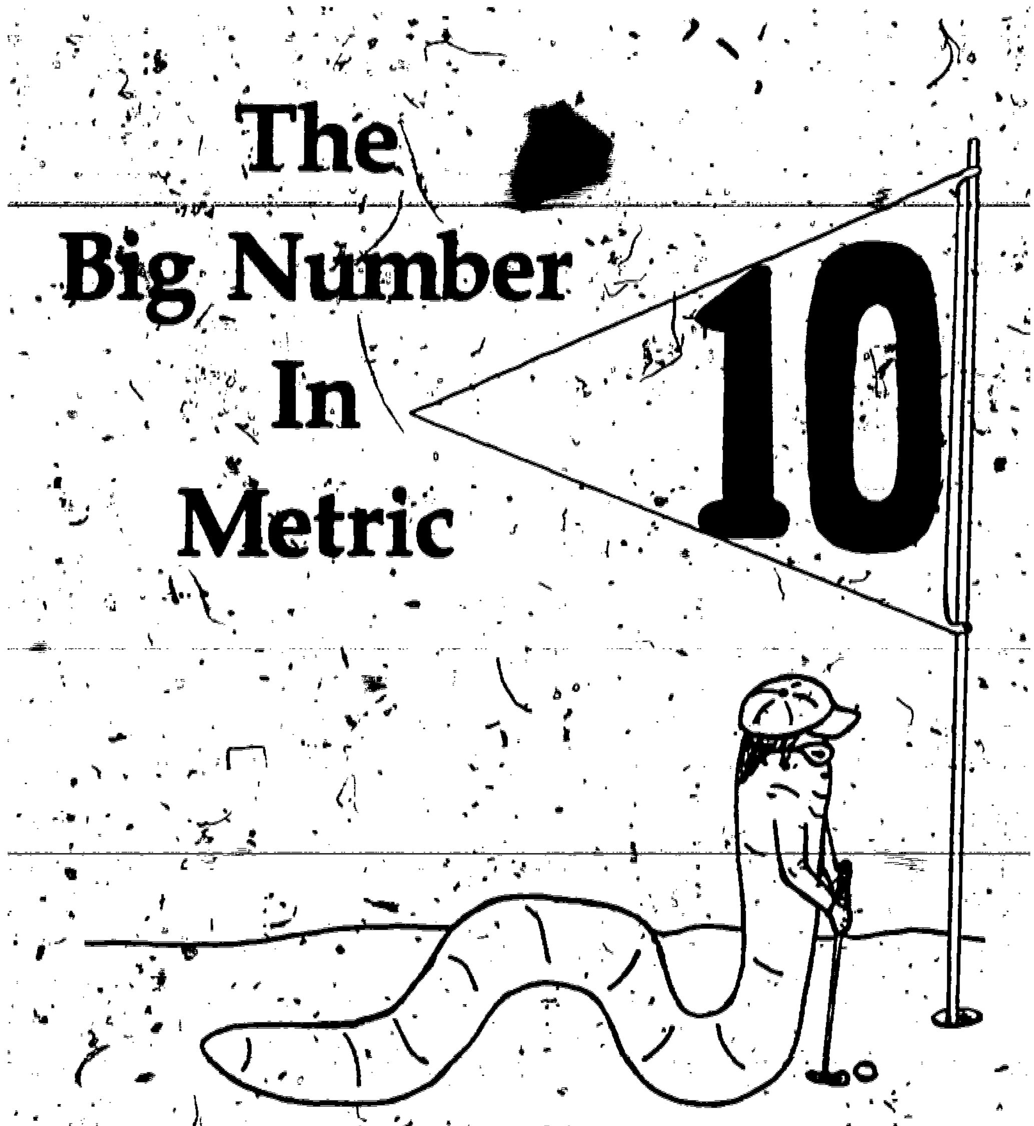
SEQUENCE FOR IMPLEMENTATION OF OBJECTIVES *

It is suggested that the foregoing objectives be implemented in the order shown below. However, the state of readiness of groups may vary and the rate of implementation may be slowed or accelerated.*

Teaching Level	First Year of Implementation	Second Year of Implementation
K	Level K Objectives	Level K Objectives
1	Level K and 1 Objectives	Level K and 1 Objectives
2	Level 1 and 2 Objectives	Level 1 and 2 Objectives
3	Level 1, 2, and 3 Objectives	Level 2 and 3 Objectives
4	Level 1, 2, 3, and part of 4 Objectives	Level 3, and 4 Objectives
5	Level 1, 2, 3, and 4 Objectives	Level 4 and 5 Objectives
6	Level 1, 2, 3, 4, and part of 5 Objectives	Level 4, 5, and 6 Objectives
7	Level 1, 2, 3, 4, and 5 Objectives	Level 5, 6, and 7 Objectives
8	Level 1, 2, 3, 4, 5, and 6 Objectives	Level 6, 7, and 8 Objectives
9/10/11/12	No specific objectives are stated here. It is expected that teachers will select from the foregoing lists those objectives sufficient to overcome deficiencies and meet the needs of students in high school grades.	

*This is from the point of view of a teacher working each year at the given grade level in a system which is uniformly changing to a multidisciplinary metric curriculum. The change will probably be completed in two years if adequate preliminary preparations are made in retraining staff and acquiring materials and equipment needed. In the third year, few "catching up" objectives should be needed, though some review will always be necessary for individual students.

The Big Number In Metric



The metric system is based on the convenience of the decimal number system. Units are related by factors of 10. This greatly simplifies computation. A great deal of the arithmetic merely involves the shifting of the decimal point without tedious calculations. This decimal nature is strikingly apparent in the following series of relationships:

10 millimeters	=	1 centimeter
10 centimeters	=	1 decimeter
10 decimeters	=	1 meter
10 meters	=	1 dekameter
10 dekameters	=	1 hectometer
10 hectometers	=	1 kilometer

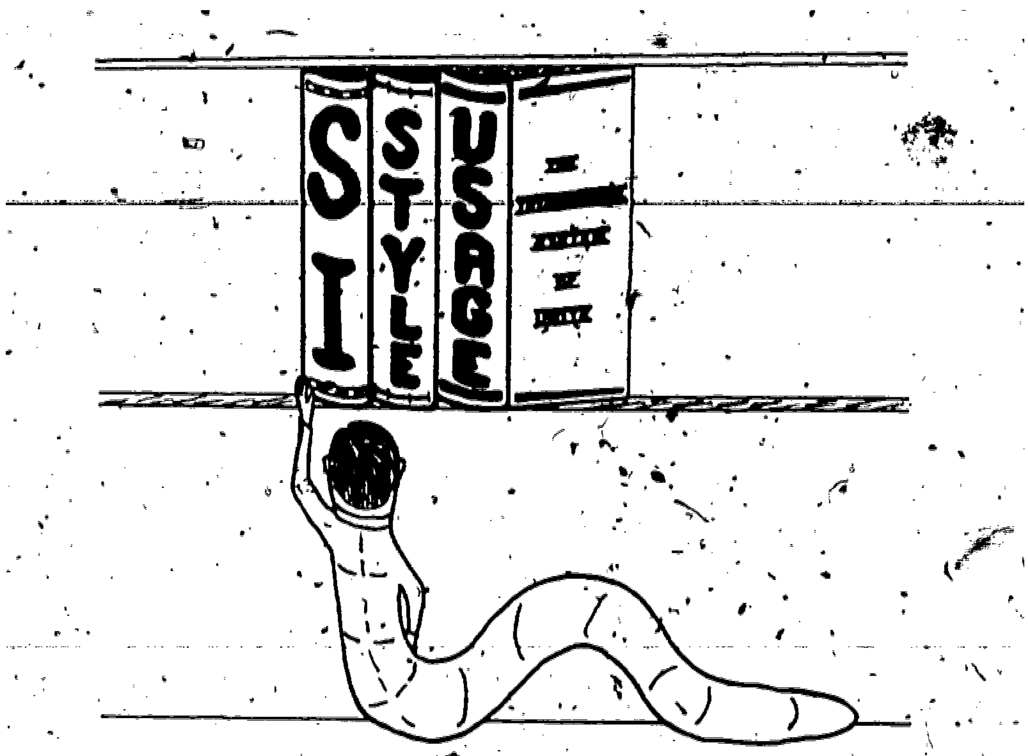
DECIMAL - MONEY - METRIC COMPARISON TABLE

Decimal Place Value	1000 thousands	100 hundreds	10 tens	1 ones	0.1 tenths	0.01 hundredths	0.001 thousandths
U.S. Money	$1000 bills	$100 bills	$10 bills	$1 bills	$.10 dimes	$.01 cents	$.001 mills
Metric Length	kilometer km	hectometer hm	dekameter dam	meter m	decimeter dm	centimeter cm	millimeter mm
Metric Capacity	kiloliter kL	hectoliter hL	dekaliter daL	liter L	deciliter dL	centiliter cL	milliliter mL
Metric Mass	kilogram kg	hectogram hg	dekagram dag	gram g	decigram dg	centigram cg	milligram mg

Prefix	Multiple of Base Unit		Power of Ten
mega	1 000 000	times	10^6
kilo	1000	times	10^3
hecto	100	times	10^2
deka	10	times	10^1
unit	1	times	10^0
deci	0.1	times	10^{-1}
centi	0.01	times	10^{-2}
milli	0.001	times	10^{-3}
micro	0.000 001	times	10^{-6}

Other useful units and symbols

hectare	ha	10,000 m²
metric ton	t	1000 kilograms
degree Celsius	°C	
Freezing point of water	0°C	
Boiling point of water	100°C	
Normal body temperature	37°C	



SYSTEME INTERNATIONAL - SI

For most teachers the metric system for teaching purposes will be four units—meter, liter, gram, and degree Celsius. More properly and for the purpose of being fully informed the real metric system (Le Système International d'Unités (SI) or International System of Units) is composed of three classes of units—base units, supplementary units, and derived units. Only teachers of advanced science and mathematics need to know the entire SI, but all teachers should be familiar with the system.

The base units and symbols are:

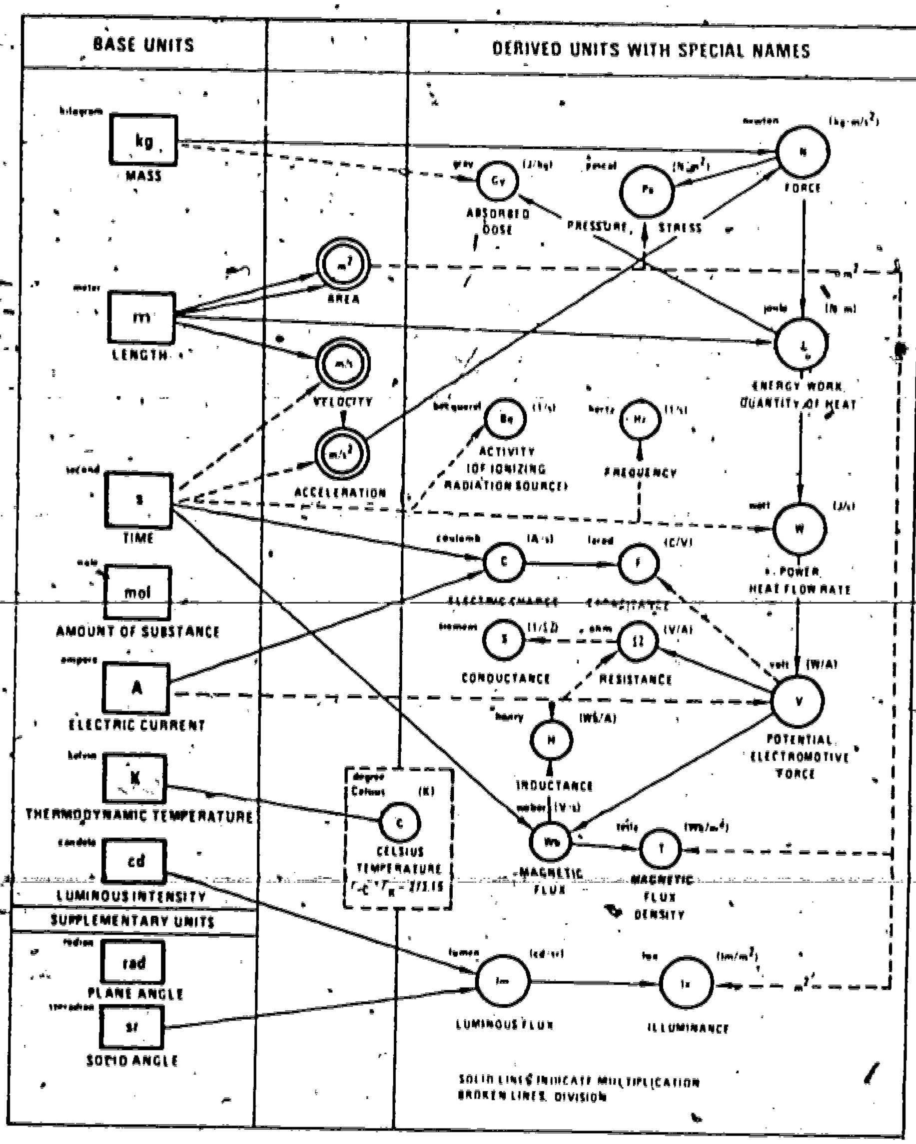
1. length	— meter, m
2. mass	— kilogram, kg
3. time	— second, s
4. electric current	— ampere, A
5. thermodynamic temperature	— kelvin, K
6. amount of substance	— mole, mol
7. luminous intensity	— candela, cd

The supplementary units and symbols are:

1. plane angular measure	— radian, rad
2. solid angular measure	— steradian, sr

The derived units are shown on the following page.

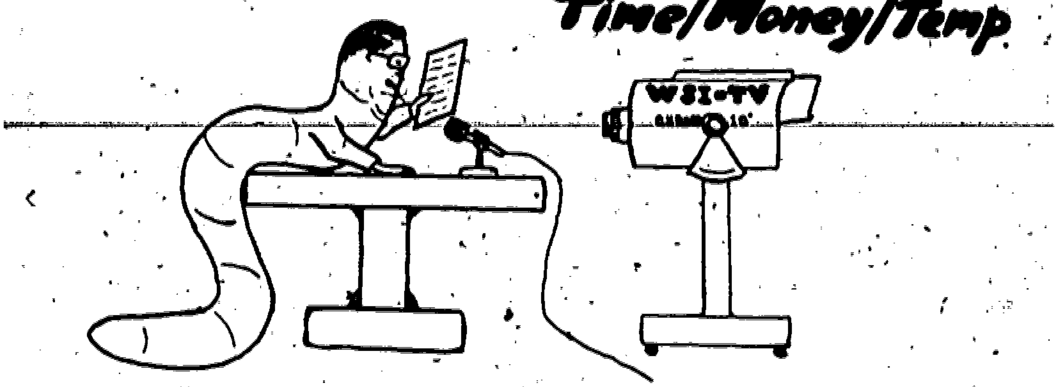
RELATIONSHIPS OF SI UNITS WITH NAMES



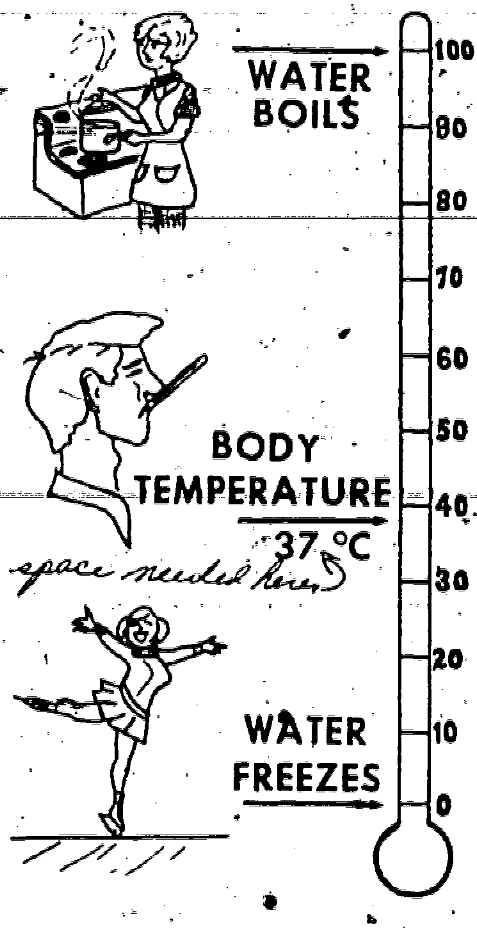
SI STYLE AND USAGE

1. Symbols are not punctuated with periods except at the end of a sentence.
   Example: kg *NOT* kg. or k.g.
2. Symbols for units do not have plural forms.
   Example: 10 kg (10 kilograms) *NOT* 10 kgs (10 kilograms)
3. A space is left between the number and the unit symbol; the only exception to this rule is for the location of the symbols used with plane angles and degree Celsius.
   Example: 25 mm, 27°C, and 90° *NOT* 25mm, 27 °C, and 90 °
4. A capital L should be used as the symbol for liter to avoid confusing it with the numeral one (1).
5. Exponential index numbers are used with symbols to signify "square" or "cubic" measure.
   Example: cm^2 (square centimeter) sq.cm. (square centimeter)
   cm^3 (cubic centimeter) *NOT* c.c (cubic centimeter)
6. The symbol for "per" is a slash "/"
   Example: Write 90 km/h or *NOT* 90 k.p.h. or 90 km per h
   90 kilometers per hour *NOT* 90 kilometers/hour
7. In recording measurements decimal form should be used instead of fractional form and when writing numbers less than one a zero is placed before the decimal point.
   Example: 0.5 *NOT* 1/2
   0.25 *NOT* .25
8. A space rather than a comma is preferred for indicating how numbers are grouped on either side of the decimal point.
   Example: 27 000 *NOT* 27,000
   3.141 592 *NOT* 3.141592
   In numbers of four digits no space is recommended.
   Example: 5000 *NOT* 5,000 *NOR* 5 000
9. Do not use a prefix as a word.
   Example: A kilogram of flour. *NOT* A kilo of flour.
10. Avoid mixing units.
    Example: 1.34 m *NOT* 1 m 34 cm
    100 cm by 20 cm *NOT* 1 m by 20 cm
11. Unit names are treated as common nouns. (Exception: Celsius is capitalized.)
    Example: kelvin, ohm, newton
12. Symbols derived from proper names are written with the first letter in upper-case.
    Example: kelvin: K
    newton: N
    degree Celsius: °C

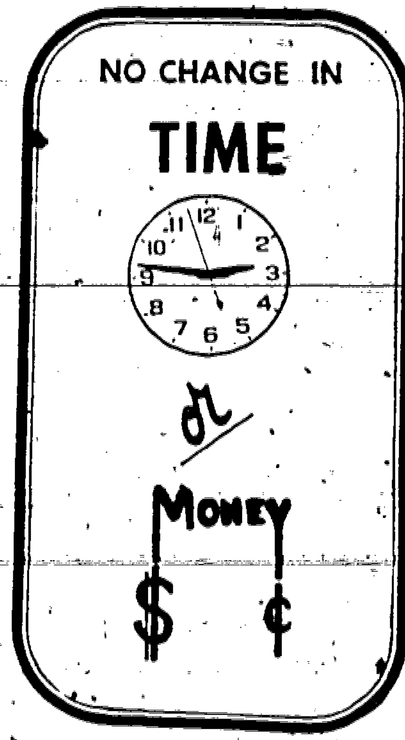
Time/Money/Temp



METRIC TEMPERATURE (CELSIUS)



No space needed here



26

The "Familiar Five:"

"Familiar Five" is not SI terminology and should not be confused with "base units" as described elsewhere in this booklet. However, these five could be appropriately referred to as basic "teaching units."

LENGTH	meter	m
MASS (weight)	gram	g
CAPACITY (volume)	liter	L
TIME	second	s
TEMPERATURE	degree Celsius	°C

Pronunciation:

In order to ensure that prefixes retain their identity when pronounced, the first syllable of each prefix is accented. Remember to pronounce kilometer with the accent on the first syllable as is the custom in pronouncing units such as kiloliter, kilogram and kilowatt. The accent on the second syllable usually applies to measuring devices such as thermometer, speedometer, barometer, and micrometer.

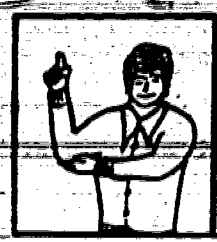
STAGES IN LEARNING TO MEASURE

1

Making Direct Comparisons

At the first stage, the child learns to make direct comparisons of objects in his environment. For example, he might compare his height with that of a member of his family.

2



Comparing With Nonstandard Units

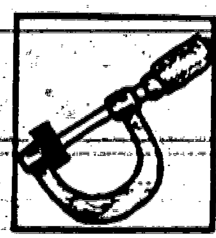
During the second stage, comparisons are made with nonstandard units. The child is able to use objects in the environment or parts of his body as units of measurement.

3

Comparing With Standard Units

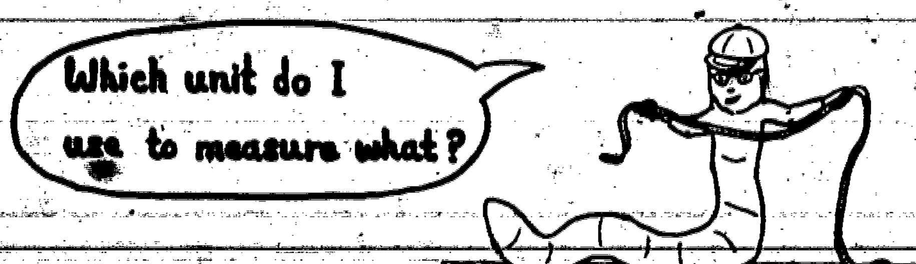
By the time the child reaches the third stage, he will have gained a concept of the different units of measurement and will be ready for the use of standard units.

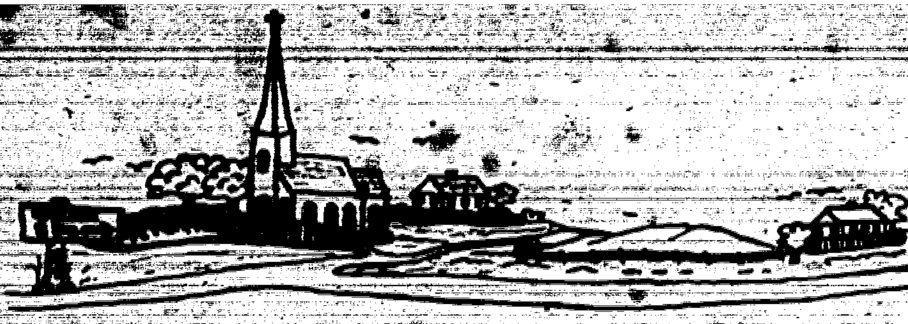
4



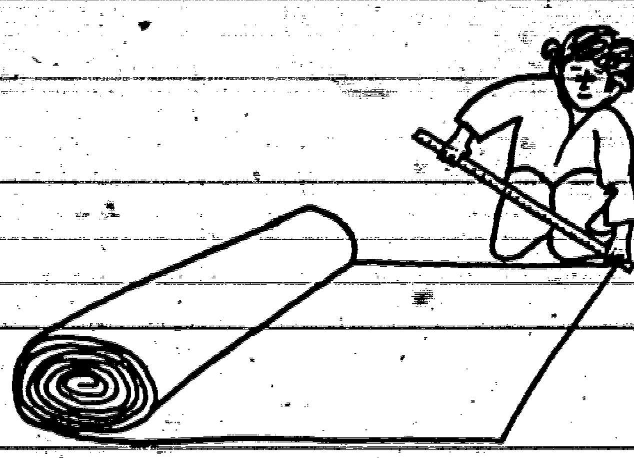
Choosing Units For Specific Tasks

During the fourth stage, the child learns to choose standard units appropriate for the measurement task at hand.





Distances between towns
are measured in kilometers.

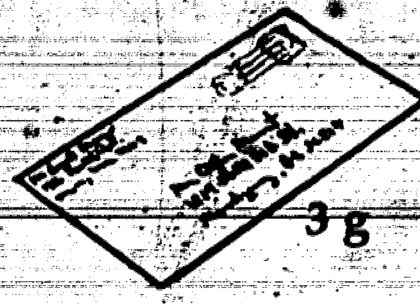


Cloth is measured in meters.

A person's height is
measured in centimeters.

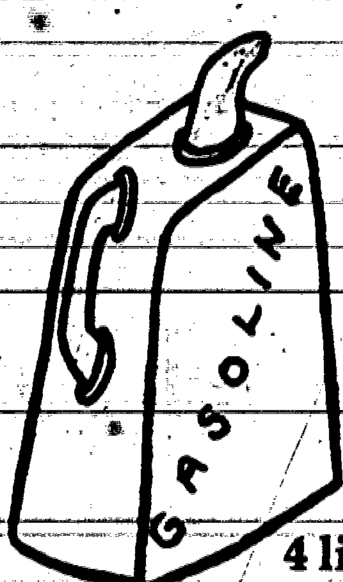
A person's mass (weight) is measured in kilograms

80 kg



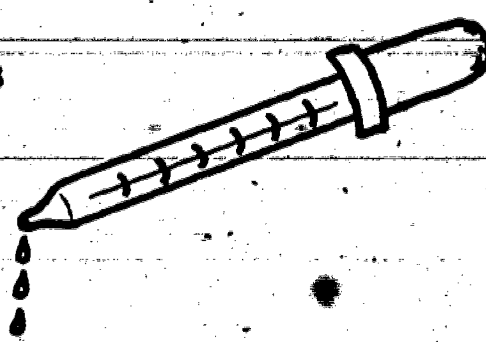
3 g

. . . smaller objects in grams.



Larger volumes of fluids are measured in liters . . .

4 liters



. . . smaller volumes in milliliters.

METRIC EQUIPMENT AND MATERIAL

There is an abundance of metric equipment and materials—some excellent, some usable, and some totally unacceptable. Let the buyer beware. There are many free materials and some which can be easily made by teachers or students. Again, take care in accepting and using these items. Consideration should be given (a) to the physical characteristics of the measuring devices to be used, e.g. safety, clarity, accuracy, durability; (b) to the grade-level appropriateness of written instructions, explanations, and exercises; (c) to the correctness and precision of written material and diagrams.

There follows a checklist for determining suitability of instructional materials and programs, and also a checklist for metric equipment.

MATERIALS AND PROGRAMS CHECKLIST

1. The materials use standard SI units in a consistent manner. (See pages 16-17)
2. Metrication is integrated into lessons throughout the curriculum and not presented as an isolated topic or limited to a single discipline.
3. Metric measures are made basic to all measurement activities. Conversion is de-emphasized in later grades and non-existent in early grades. Where conversion is necessary, it is dealt with from a metric basis.

4. Measurement activities follow a developmental sequence which reflects a genuine concern for how and when children learn to measure.

5. The development of the concept of measurement is considered when selecting classroom tools and written materials.

a. Non-numerical matching and comparison
b. Ordering
c. Appropriate language
d. Estimation
e. Numerical relations and mapping
f. Pictorial representation—use of scale drawings
g. Calibration and use of instruments

EQUIPMENT CHECKLIST

1. Is the measuring device accurately calibrated? Many suppliers will have information available on the standards to which their equipment is produced. Compare calibrations.
2. Are calibrations permanent or are they apt to wear off (or get scratched off) in a short period of time?
3. Is the device durable? Can it withstand the rigors of child use? Drop it. Squeeze it. Test it.
4. Does the measuring device fit the use it is being purchased for? Example: Thermometers with a range of −10°C to 50°C cannot be used to find the temperature of boiling water.
5. (Liquid Containers) Children hesitate to fill containers to the top with liquids. Therefore, calibrations should not be made to the very top.
6. Is the device appropriate for the children who will be working with it? Example: An analytical balance might not be appropriate for early elementary children, however, a simple balance beam might be appropriate.
7. Is it easily repaired? Are parts available?
8. Is it attractive? Will children want to pick it up and play with it?
9. Can it be used for many applications? Are instructions included?

A MINIMAL LIST OF METRIC EQUIPMENT AND MATERIALS KINDERGARTEN - THIRD GRADES

Quantity	
8	Combination meter sticks
5	Meter sticks scaled only in meters
5	Meter sticks scaled only in decimeters

5	Meter sticks scaled only in centimeters
6-8	Flexible tapes, 150 cm long, scaled in centimeters
1	Ten-meter tape scaled in meters and centimeters
30	30 cm rulers scaled in centimeters (Should measure from the end of the ruler.)
10	Celsius thermometers, range at least −30°C to 110°C. (Calibrations should be in 2°C divisions.)
2 sets	Metric weights including a kilogram weight (metal, plastic, or a combination of these)
2	Pan balances
1	Metric bathroom scale (metric units only preferred)
2-3	Liter containers (plastic)

Other Desirable Metric Equipment and Materials

Quantity	
2	Trundle wheel with clicker, preferably free-turning in either direction
1	Height measuring device
1-2	50 Meter tape scaled in meters and centimeters
2-3	Bucket balance
1 set	Cuisenaire Rods (classroom set, in individual containers)

FOURTH - SIXTH GRADES

Quantity	
15	Meter sticks scaled in centimeters
30	30 cm rulers scaled in millimeters
30	Square centimeter transparent grids (at least 10 cm × 10 cm)
1000	Cubic centimeter blocks (plastic, weighing one gram)
1	Celsius room thermometer (wood back preferred)
3	Celsius dipping thermometers
10	Celsius thermometers, range at least −30°C to 110°C (Calibrations should be in 2°C divisions.)
6-8	Flexible tapes, 150 cm long, scaled in centimeters and millimeters (possibly in decimeters also).

1	10 Meter tape scaled in centimeters
1	50 Meter tape scaled in centimeters
5-6	Pan balances
1 Ream	Square centimeter graph paper or a duplicator master for such paper
1	Metric bathroom scale (metric units only preferred)
1 set	Containers for liquids (1 L, 500 mL, 250 mL as a minimum)
1	Dissectible liter cube (cubic decimeter)
10	100 mL graduated cylinders scaled in at least 10 mL divisions (soft plastic preferred)

Other Desirable Metric Equipment and Materials

Quantity	
1	Cubic meter (could be just clips in which to insert meter sticks)
2-3	Spring scales (at least 1 kg, with at least 100 g divisions)
1	Height measuring device
2 each	500 mL and 100 mL graduated cylinders (soft plastic)

SEVENTH - TWELFTH GRADES

Quantity	
5	Meter sticks scaled in centimeters
30	30 cm rulers scaled in millimeters
30	Square centimeter transparent grids (at least 10 cm × 10 cm)
1000	Cubic centimeter blocks (plastic ones that weigh one gram preferred)
1	Celsius room thermometer (wood back preferred)
10	Celsius thermometers (range at least −30°C to 110°C)
6-8	Flexible tapes, 150 cm long, scaled in centimeters and millimeters (possibly in decimeters also).
1	50 meter tape scaled in centimeters
1 Ream	Square centimeter graph paper or a duplicator master for such paper

1 set	Containers for liquids (1 L, 500 mL, 250 mL as a minimum)
1	Dissectible liter cube (cubic decimeter)
10	100 mL graduated cylinders scaled in at least 10 mL divisions (soft plastic preferred)

Other Desirable Metric Equipment and Materials

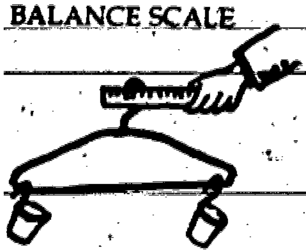
Quantity	
2-3	Metric calipers, inside and outside, with spring-lock scaled in centimeters and millimeters
1	Metric bow calipers (scale on base)
1	Metric depth gauge (may be incorporated on calipers)
1	Surveyor's chain (metric dimensions)
30	Geoboards

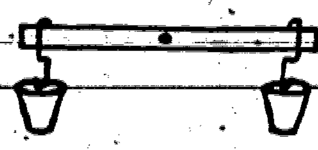
OTHER USEFUL ITEMS

- 5 mL plastic spoons
- Weighmix scale (a kitchen scale which can be reset to zero)
- 50 mL medicine cups (obtainable from a hospital supply house)
- Self-adhesive tape marked in centimeters
- Paper tape (Adding machine tape will serve well.)
- Metric spoon set. 1, 2, 5, 15, 25, mL spoons
- Geoboards

CLASS-MADE LEARNING AIDS

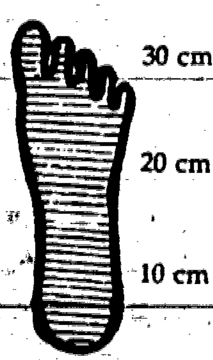
BALANCE SCALE





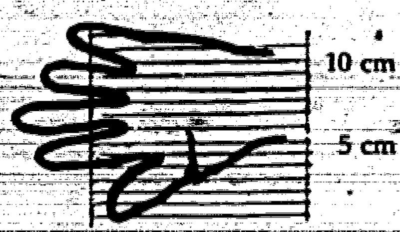
Bent coat hanger with gem clips holding styrofoam or paper cups, or ruler with pin at center point and cups hung with gem clips.

FOOT MEASURER



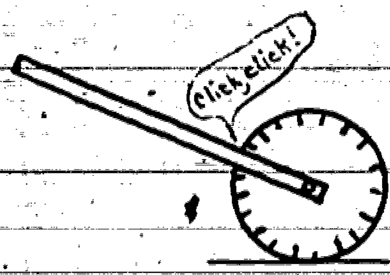
Paste cardboard foot on floor with centimeter scale. Cover with contact paper.

HANDSPAN MEASURER



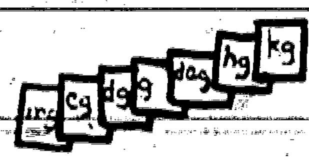
Paste cardboard hand on wall with centimeter scale. Cover with contact paper.

LONG DISTANCE MEASURER



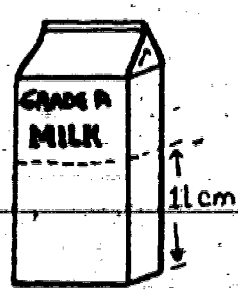
A trundle wheel can be made using a circular piece of wood with a diameter of slightly less than 32 cm (31.86 cm) which will give a circumference of one meter. Drill a hole through the center of the disc and through the end of a broom handle or other stick. Join the two with nut, bolt, and washers to permit easy rotation. Divide the wheel circumference with dm, cm, and one meter marks. A metal tab can be attached at the one meter mark so that a click is made as each meter is measured.

PLACE VALUE, PREFIX VALUE, AND SYMBOL CHARTS



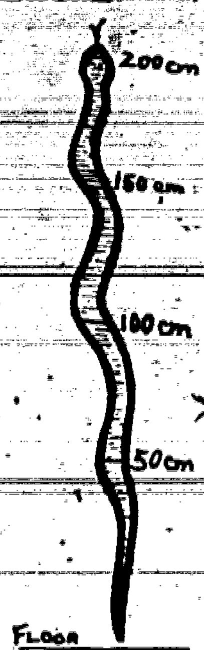
Sets of seven cards, cardboard, paper, or other surfaces can be labeled with place values, prefix values, or symbols.

LITER CONTAINERS



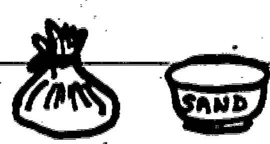
Use 7-Up or Coke liter bottles. One pound coffee cans are approximately one liter. Also, a half gallon milk carton cut 11 centimeters from base will hold one liter. Cut 12 centimeters from base to allow for spillage.

HEIGHT MEASURER



Tape or paste a two-meter cardboard "tree" or "snake" to wall. Mark in centimeter scale. Cover with contact paper. Have a straightedge to place on top of head at correct height.

MASS MEASURERS



Fill heavy duty plastic bags or containers with aggregate corresponding to various masses—gram to kilogram

LINEAR MEASURERS

Let students make decimeter and 10 centimeter strips which can be joined to make a meter measurer. Adding machine tape, manila folder strips, or any paper covered with contact paper can be used.